DDT Concentrations in Human Milk

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Human milk from seven US cities was analyzed for total DDT (DDT plus DDE) content. The mean of 138 samples was 0.17 ppm (range, <0.02 to 0.83 ppm) which is in excess of the World Health Organization's recommended maximum concentration in cow's milk (0.05 ppm.)

Use of commercial exterminators was associated with lower DDT levels than was personal home use of pesticides; donors using butter had lower concentrations than those using margarine. DDT levels diminished with increasing maternal age and milk obtained after nursing contained significantly more DDT than milk obtained at the start of nursing.

While no adverse effects to infants due to DDT in human milk has been documented, systematic monitoring of DDT and other environmental pollutants in man is needed.

Concern has been expressed in both the scientific literature[1,2] and the lay press[3] over the concentrations of DDT and its metabolites in human milk. This has resulted in some worry to women breast-feeding or planning to breast-feed infants.

The magnitude of public discourse has been somewhat disproportionate to the extent of the data. The number of pesticide residue determinations in human milk is small and the colorimetric methods employed in earlier work are open to some question.[4]

Only eight articles have appeared in the English language literature over the 27 years, 1945 to 1972—a period of great change in the extent of pesticide use. As reviewed by Ritcey et al,[5] seven additional studies have been published in the USSR and 12 in European countries. At present, the data are not sufficient to delineate geographic, racial, socioeconomic, and other possible variations in DDT concentrations in human milk. Preliminary data bearing on some of these questions are presented here.

Materials and Methods

Samples of human milk were obtained from white, urban, middle-class donors residing in several towns on Long Island and in Rochester, NY; Chicago; Lexington, Ky; Nashville and Memphis, Tenn; and Los Angeles. Samples were obtained during the period from June 1970 through October 1971. Donors also completed a brief questionnaire regarding their exposure to pesticides, food habits, and weight gain or loss. Samples were kept frozen in polyethylene bags or in glass bottles until analysis. Chlorinated hydrocarbon pesticides were extracted from these samples by the method described by Schafer et al.[6] Ten milliliters of the milk was saponified with potassium hydroxide solution (25% solution of potassium hydroxide) and then extracted with 10 ml of hexane. The hexane extract was then sealed in a glass ampule until analysis. This method of sample preparation quantitatively converts DDT to DDE and results will be expressed as concentrations of total DDT.

Quantification of DDE was achieved with a gas chromatograph equipped with an electron capture detector, field-emission type, or with another gas chromatograph also equipped with a radioative nickel electron capture detector (^{63}Ni). The field-emission electron capture detector (ECD) was calibrated with standard aliquots (2 to 10 ng) of DDE (Varian Associates Nanogen Pesticide Standards) in benzene which also established the linear range of this ECD. Each analysis of 10μl to 20μl portions of the hexane extracts was followed by an injection of the analytical standard (DDE) to compensate for the drift of the field-emission ECD. The ^{63}Ni ECD was calibrated with several aliquots of the analytical standard (0.05 to 0.20 ng DDE); a standard was also injected after each sample analysis to insure reliability. Samples which indicated high levels of DDE on first analysis were diluted 1:10 so that a 1μl to 2μl injection would deliver a quantity of DDE known to be in the linear range of detection to the ^{63}Ni ECD.

Sample analyses were equally well accomplished on a 2 meter × 3 mm column of 10% DC-200 on Anakrom ABS 80/90 mesh support at 197 C (also used at 210 C) and a 2 meter × 3 mm column of 3% Dex 300 on Chromosorb G-HP 80/100 diatomite mesh support at 215 C. Two other diatomite support columns were used to confirm the identity of DDE in selected samples: a 2 meter × 4 mm column of mixed 5% QF-1 and 5% SE-30 on Chromosorb W60/80 mesh (acid washed), and a 2 meter × 4 mm column of 25% SF-96 on Chromosorb W60/80 mesh (acid washed).

Blank analyses were run on distilled water samples to establish that reagents were not introducing spurious results. Preliminary studies using commercial cow's milk demonstrated that the plastic bags used for storage did not contaminate the samples. Analyses of fresh milk and milk which had been stored frozen in plastic bags for two months showed no discernible differences.

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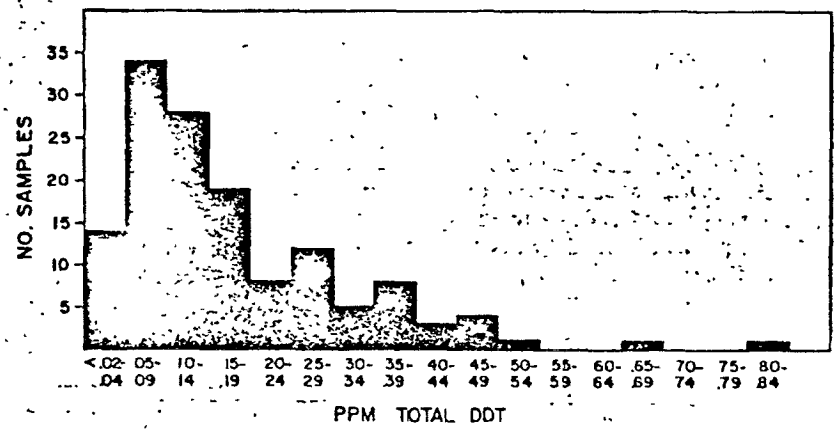

Frequency distribution of human milk samples by concentration of total DDT.

Table 1.—Total DDT Concentrations in Human Milk by City of Origin

City	No. Samples	Mean, ppm	Standard Deviation	P*
Long Island	14	0.100	0.10	.01
Rochester	20	0.17	0.13	NS†
Chicago	19	0.18	0.10	NS
Lexington	27	0.22	0.17	NS
Nashville	34	0.17	0.15	NS
Memphis	6	0.15	0.08	NS
Los Angeles	18	0.18	0.12	NS

* Probabilities of the difference between the corresponding mean and the mean of the total population being due to chance.
† Not significant.

Table 2.—Home Pesticide Use, Exterminator Use, and DDT in Human Milk

	No. Samples	Mean, ppm	Standard Deviation
Home Use			
Does not use pesticides	81	0.17	0.14
Uses pesticides	52	0.18	0.14
Exterminator Use			
No exterminators	107	0.18	0.15
Uses exterminators	30	0.14	0.10

Results

A total of 138 samples of human milk from 101 donors was analyzed. The mean total DDT concentration was 0.17 ppm with a standard deviation of 0.14 ppm. The range of concentrations was from less than 0.02 ppm to 0.83 ppm (Figure). Only four specimens had undetectable concentrations of total DDT (< 0.02 ppm) and three had concentrations in excess of 0.50 ppm.

The results are presented according to geographic area in Table 1. The mean concentration of the samples from the Long Island communities (0.10 ppm) is significantly lower than those from the other cities ($P = .01$). The mean of the Lexington samples exceeded that from the other areas, but this difference did not achieve statistical significance.

Of particular interest was the relationship of total DDT concentrations to prior reported exposure to pesticides (Table 2). Of the women, 39% had used pesticides in their homes or gardens, but there was not a statistically significant difference in the total DDT concentrations in the milk from the two groups. However, when those women employing exterminators were compared with those who used pesticides on their own, it was found that exterminator use was associated with lower concentrations of total DDT in the milk ($P = .05$). Frequent pesticide exposures at some time in the past, usually associated with agricultural activities, were reported by 26 women. The concentrations of total DDT in their milk did not differ significantly from those who were not so exposed.

Regarding diet, no significant correlations could be found between total DDT concentrations in milk and

Table 3.—DDT in Human Milk and Use of Butter or Margarine

	No. Samples	Mean, ppm	Standard Deviation
Butter	31	0.14	0.10
Margarine	40	0.20	0.16

Table 4.—Total DDT Concentrations (ppm) in Matched Fore-Milk and Hind-Milk Samples

Fore-Milk	Hind-Milk	Difference
0.09	0.13	+0.04
0.04	0.12	+0.08
0.06	0.16	+0.10
0.13	0.26	+0.13
0.03	0.06	+0.03
0.04	0.08	+0.04
0.23	0.35	+0.12
0.10	0.21	+0.11
0.05	0.17	+0.12
0.29	0.37	+0.08
0.11	0.12	+0.01
0.14	0.16	+0.02
0.68	0.45	−0.23
0.29	0.52	+0.23
0.11	0.35	+0.24
0.06	0.09	+0.03
0.06	0.46	+0.40
0.16	0.11	−0.05
0.13	0.15	+0.02
0.07	0.09	+0.02
0.16	0.04	−0.12
0.06	0.18	+0.12
0.37	0.48	+0.11
0.03	0.24	+0.21

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the number of days per week the donor ate meat or fish. However, when those women who used butter and margarine were compared (Table 3), those using margarine had a higher concentration of total DDT in their milk than did those who used butter ($P < .04$).

While there was no correlation with the infant's age at the time the milk sample was donated, there was a negative correlation between the mother's age and the total DDT concentration in her milk, ie, the older the mother, the lower the concentration tended to be.

Twenty-four matched pairs of milk samples were obtained. Milk from a full breast (fore milk) was compared with milk from a nearly empty breast (hind milk) from the same donor at the same feeding. The two sets of samples showed a striking difference (Table 4): the total DDT concentration was significantly higher in the hind milk ($P < .01$).

We sought to determine the dependence of milk DDT concentration upon the date of sample collection. These preliminary results suggest a seasonal dependence of total DDT concentration, with DDT concentration in the late summer ranging up to 60% (0.08 ppm) higher than DDT concentration in the latter part of the winter. Additional specimens obtained over an extended period of time will be needed to verify this seasonal periodicity.

Comment

Organochlorine pesticides are now universal pollutants; they can be detected in virtually all animal tissues, even those sampled in remote parts of the earth far from areas of large-scale pesticide use.[9] It is now accepted that low tissue concentrations of such pesticides may produce subtle injury to species of birds, fish, and other nontarget organisms.[9, 10] Concern over the potential effects of pesticide residues in man has led to extensive routine food-monitoring programs in this and other countries and upper limits of acceptable pesticide concentrations have been set for many food items including milk.

The monitoring of man has been considerably less extensive and less standardized; milk is a pertinent example. The World Health Organization (WHO) has set a practical residue limit for total DDT in cow's milk of 0.05 ppm.[11] The Food and Drug Administration uses this value as the maximum permissible concentration of total DDT in the regular monitoring of commercial cow's milk shipped in interstate commerce. The recent public controversy regarding breast milk apparently emanates from newspaper reports of the higher concentrations of DDT in human milk.[3] As has been noted, the data base supporting these reports is, in comparison to that for cow's milk, extremely small. Nevertheless, it and the results of the current study do support the general conclusion that human milk contains a higher concentration of total DDT than does cow's milk.

The higher concentration of DDT in human milk is not an unexpected finding. Pesticides tend to become more concentrated as one samples up a food chain[12]: that is, meat-eaters (including man) store more DDT in their tissues than do herbivores, such as cattle. Hence, human milk would be expected to contain more DDT than that from cows.

The mean concentrations of total DDT in all seven geographical areas sampled in this study were in excess of the WHO upper limit for cow's milk. This was also the case in the two recent publications that reported on samples from various parts of Pennsylvania[13] and Canada.[5]

The WHO maximum admissible daily intake of DDT is set at 0.01 mg/kg of body weight.[11] Thus, a 4 kg infant ought not ingest more than 0.04 mg of DDT per day. If an infant drinks approximately 650 ml of milk per day,[14] the milk must contain less than 0.06 ppm DDT if the WHO limit for cow's milk is not to be exceeded. The mean in our study was 0.17 ppm.

It is imperative to state at this point that we know of no demonstrated damage to breast-fed infants from DDT. Furthermore, the study of Hayes et al[15] indicates that adult men are not injured directly by prolonged high-level oral doses of DDT. Increased mortality among neonatal rats nursing very heavily DDT-treated mothers has been reported,[16] but the relevance of that study to man is conjectural. The absence of a direct connection with illness notwithstanding, it appears prudent to monitor human breast milk for pesticide content.

Both biological and environmental factors correlating with the concentration of DDT in breast milk were revealed in this study. Although the sample size is among the largest in the literature, it is still small and the results are regarded more as an impetus to further study than as a definitive investigation.

The lower DDT content in the milk from the Long Island communities suggests that there may be significant variation with geographical area. We have no explanation for this observation.

Pesticide exposure was a less clear correlate than expected. Large-scale exposure in the past was not associated with increased DDT content, nor was personal home use of pesticides. The employment of exterminators seemed to be protective, however: it is known that commercial operators rarely use organochlorine pesticides in dwellings. The suggestion of a seasonal influence on milk DDT concentration might be due to environmental factors such as seasonal changes in diet or changes in domestic or garden use of pesticides.

Eating margarine rather than butter was associated with higher DDT concentrations. While we are reluctant to imply a directly causal relationship with this single dietary item, it is of interest that margarine is made largely of cottonseed oil and that DDT has been used extensively in the cotton industry.[17] Some direct measurements of DDT residues in margarine and butter have been made during the period from 1964 to

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1966, the Food and Drug Administration performed analyses on 53 samples of margarine, 18.9% contained DDT with an average concentration of 0.026 ppm. In 1967, 13% of 23 samples contained an average of 0.014 ppm DDT.[9]

In contrast, during 1970, 100 butter samples were analyzed, 23% contained DDT with an average concentration of 0.005 ppm. In 1971, 5% of 84 samples contained only trace amounts of DDT (J.R. Wessel, Food and Drug Administration, written communication, August 1972). These data support the hypothesis that consumers of margarine are more apt to be exposed to DDT residues than are those who eat butter. It is suggested that nursing mothers eat butter rather than margarine.

The biological variations in pesticide content of breast milk revealed in this study require that future sampling be more precisely defined than in the past. The very significant increase in total DDT content of hind milk as compared with fore milk was the most striking variation encountered. Also of importance was the diminishing DDT concentration with increasing age of the donor. This relationship is consistent with Kroger's observation[13] that DDT content appears to decrease with the increasing number of children nursed by the mother. Future work should specify fore or hind milk collections and include age- and parity-specific concentrations.

We wish to reiterate that we know of no demonstrated danger from DDT to breast-fed infants which would warrant giving up the known advantages of breast-feeding. Nevertheless, we do feel that DDT concentrations in human milk should be more widely investigated in different geographic, socioeconomic, and racial groups and that the various biological factors affecting DDT excretion in human milk receive attention.

Household uses of DDT were banned by the Department of Agriculture during the autumn of 1969. On June 14, 1972, the Administrator of the Environmental Protection Agency issued a ban on the general use of DDT which took effect on January 1, 1973.[19] In 1970, the last year for which data are are available, approximately 25 million pounds of DDT were used in the United States (B. Fielding, Environmental Protection Agency, oral communication, December 1972). Public health, quarantine uses, and a few minor crop uses of DDT are exempted from the general ban and are estimated to require a few thousand pounds of DDT annually. As of this writing, several industrial groups are suing to gain exemptions for certain other agricultural uses. The ban will go into effect while these suits are in progress, but should the exemptions be granted, usage is estimated to be about one half million pounds of DDT per year. The order also does not affect exports of DDT for use in other countries; therefore, significant amounts of this pesticide will continue to enter the earth's ecosystem.

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